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Diet Composition of Horse Mackerel, *Trachurus mediterraneus ponticus* Aleev, 1956 (Osteichthyes: Carangidae) in the Bulgarian Black Sea Waters

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Abstract

Present analysis was performed on samples of horse mackerel *Trachurus mediterraneus ponticus* Aleev, 1956 collected at monthly intervals (April - September 2007) off the Bulgarian Black Sea territorial waters. Stomach contents of 1042 specimens were analyzed. Of the total number of examined stomachs, 597 were empty (57.3%). This percentage varied significantly with season, the maximum number of empty stomachs was observed during spring (52.3%) and a minimum number observed during summer (32.4%). The mean weight of stomach contents increased significantly for fish larger than 16 cm TL, while the mean number of prey items significantly declined in the large –size classes. Mean weight of stomach contents and mean number of prey significantly increased in spring-summer period. The stomach content consisted of several major prey groups: Crustacea (Copepoda, Cladocera, Mysidacea, Ampipoda, Isopoda, Decapoda), Polychaeta and Pisces. Mysidacea were the most important ingested prey, especially in small and medium size classes. *Sprattus sprattus phalericus* L. and *Engraulis encrasicholus ponticus* L., whose proportion increased in large size classes, were the most important food categories. Cladocera were food category with especially abundant in summer, while Amphipoda, Isopoda, Polychaeta and Decapoda were occasional foods. With fish growth, the proportion of planktonic organisms decreased, while that of fish increased. Feeding intensity varied throughout the year. The lowest feeding intensity was recorded in spring and the highest feeding intensity was recorded in summer.

Key words: *Trachurus mediterraneus ponticus*, horse mackerel, stomach contents analysis, food composition, feeding intensity, Black Sea.

Introduction

Species from family Carangidae are widespread in the Mediterranean, Black and Azov Seas. (Stoyanov *et al*., 1963). Family Carangidae in the Black Sea is represented by *Trachurus trachurus* and *Trachurus mediterraneus ponticus*. In the Bulgarian Black Sea, territorial waters were distributed with only *Trachurus mediterraneus ponticus*. In the Black Sea, entering of the separate *Trachurus trachurus* specimens from Sea of Marmara is a quite rare phenomenon (Stoyanov, 1963). Horse mackerel is pelagic, summer spawning fish with Mediterranean origin and landings in front of the Bulgarian Black Sea coast occur during spring and autumn (Maximov, 1914). *Trachurus mediterraneus ponticus* are rather widely distributed in Black Sea and play an important role in commercial fisheries although the values of Bulgarian catches of this species are fluctuated from 165 to 56.84 tons in a period from 1992 to 2007 (Anonymous, 2007). The biological characteristics are subject of long-term investigation by number of authors: Aleev (1957; 1959), Georgiev and Kolarov (1962), Ivanov and Beverton (1985), Prodanov *et al*. (1997), Tichonov *et al*. (1955). Limited knowledge regarding the trophic ecology of this species in Bulgarian Black Sea waters exists. Information on the diet of *Trachurus trachurus* (L. 1758) in the Portuguese coast indicates that it is main diet comprises crustaceans (Cabral and Murta, 2002). Descriptions of *Trachurus mediterraneus* diet in Izmir Bay state that the main food items are Mysidacea, Brachyural larvae and Copepoda (Sever and Bayhan, 1999). Descriptions of the horse mackerel diet in European waters state that the main food items are copepods, decapods, fish eggs and larvae, small fish and cephalopods (Letaconnoux, 1951; Planas and Vives, 1953; Anadon, 1960; Dahl and Kirkegaard, 1987; Ben Salem, 1988; Olaso *et al*., 1999). Data on feeding habits of horse mackerel in the Bulgarian Black Sea waters were presented by Stoikov (1978) and Stoyanov *et al*. (1963). Namely, Stoyanov *et al*. (1963) reported that *Trachurus mediterraneus ponticus* living in the Bulgarian territorial waters feed in summer with different development stages of small fish (anchovy, sprat) and crustaceans such as Mysidacea. The same authors revealed that zooplankton formed the food of young individuals. The diet of horse mackerel along the Bulgarian Black Sea coast as described by Stoikov (1978) consists of mainly crustaceans, worms and fish. However, very little is known about the trophic ecology of horse mackerel in the Bulgarian Black Sea waters. The goal of the present study was to determine diet composition of horse mackerel, *Trachurus mediterraneus ponticus* in the Bulgarian Black Sea waters during the 2007 fishing season.

Materials and Methods

Samples of horse mackerel *Trachurus mediteraneus ponticus* were taken from two localities (Varna and Bourgas) off the Bulgarian Black Sea coast (Figure 1). A total of 1,042 specimens were collected at monthly intervals, May–September 2007. Samples were taken from commercial, pelagic-trawl catches taken with a cod-end of 6.5 mm stretched mesh size. Total length (TL) of fish examined was measured to the nearest 0.1 cm and they were weighed to the nearest 0.1 g. Immediately after capture, fish were dissected and gut removed and preserved in 4% formalin solution to stop digestion. Species abundance and wet weight, to the nearest 0.001 g after removal of surface water by blotting on tissue paper, were recorded in the laboratory. Total length of fish examined ranged from 11.0 to 17.5 cm (Figure 2). Numerous indices have been described for quantitatively expressing the different prey in diet of fish (Berg, 1979; Hyslop, 1980). Those used in the present study were:

Percentage frequency of occurrence (F%), based on the number of stomachs in which a food item was found, expressed as the percentage of total number of non-empty stomachs;

Percentage of numerical abundance (Cn%) i.e. the number of each prey item in all non-empty stomachs, expressed as the percentage of total number of food items in all stomachs in a sample;

Percentage gravimetric composition (Cw%) i.e. the wet weight of each prey item, expressed as the percentage of total weight of stomach contents in sample.

The main food items were identified using the index of relative importance (IRI) of Pinkas *et al*. (1971), as modified by Hacunda (1981):

$$IRI = \%Fx\ (\%Cn + \%Cw)$$

This index has been expressed as:

$$\%IRI = (IRI/\sum IRI) \times 100$$

Statistical differences ($P<0.05$) in diet composition with respect to size and season were assessed by a chi-square test (Sokal and Rohlf, 1981) applied on the frequency of a given prey.

Figure 1. Study area and sampling localities of horse mackerel, *Trachurus mediterraneus ponticus L.* in the Bulgarian Black Sea waters.

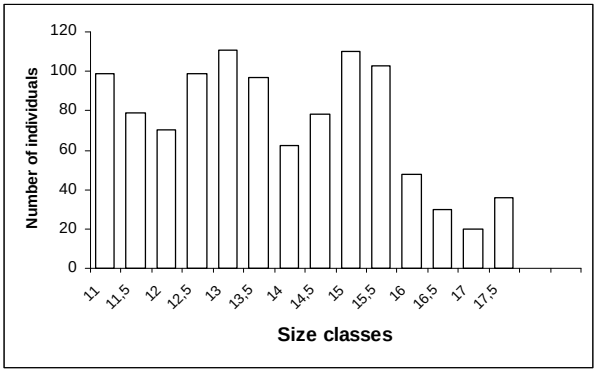

Figure 2. Length frequency distribution of 1042 individuals of horse mackerel caught in the Bulgarian Black Sea waters.

Results

Feeding Intensity

Of the 1,042 stomachs of Black Sea horse mackerel examined, 597 were empty (57.3%). This percentage varied significantly among the size classes, with a maximum of 68.1%-size class 12.5 cm and minimum of 31.9%-size class 17.0 cm The proportion of empty stomachs varied over the examination period, minimum proportion of empty stomachs was found in summer (32.4%) while in samples collected in spring and autumn, proportion of empty stomachs was 52.3% and 41.0% respectively (Figure 3).

Diet Composition

The stomach contents of horse mackerel *Trachurus mediterraneus ponticus* consisted of several prey species belonging to following taxa: Crustacea (Copepoda, Cladocera, Mysidacea, Ampipoda, Isopoda, and Decapoda), Polychaetous worms and Pisces. Table 1 shows the frequency of occurrence, numerical and biomass composition and Index of Relative Importance of different prey groups

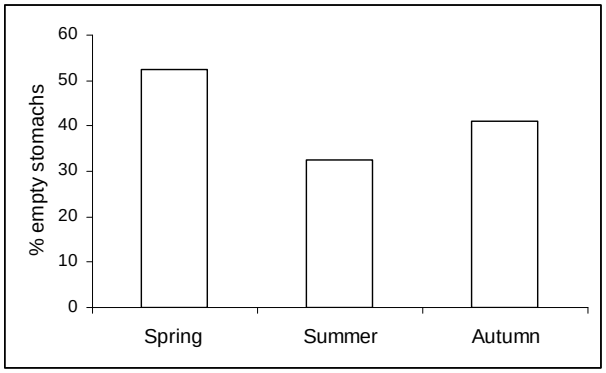

Figure 3. Percent (%) of number of empty stomach by season.

Table 1. Prey groups and species in diet of horse mackerel, *Trachurus mediterraneus ponticus*

Food items	%F	%Cn	%Cw	IRI	%IRI
Polychaeta					
Terebellides stroemi (Sars)	13.37	0.35	2.34	35.96	13.81
Crustacea					
Copepoda					
Acartia clausi (Giesbracht)	12.29	1.84	2.13	44.9	17.25
Calanus helgolandicus (Claus)	0.59	0.35	0.20	0.32	+
Pseudocalanus elongates (Beock)	17.86	0.73	0.38	19.8	7.61
Mysidacea					
Mesopopsis slabberi (van Beneden)	1.61	5.42	2.10	12.11	4.65
Paramysis lacustris (Mart)	2.19	0.13	1.86	4.33	1.66
Cladocera					
Podon polyphemoides (Lueckart)	1.51	0.06	1.63	2.55	+
Evadne tergestina (Claus)	1.17	0.08	2.40	2.90	1.11
Evadne nordmani (Loven)	5.12	0.41	0.10	2.6	1.0
Penilia avirostris (Dana)	7.38	0.15	0.04	1.4	+
Amphipoda					
Dexamine spinosa (Mont.)	0.37	0.008	0.11	0.04	+
Ampelisca diadema (A.Costa)	2.35	0.15	2.29	5.73	2.20
Gammarus subtypicus (Stock)	0.95	0.44	2.36	2.66	1.02
Isopoda					
Idothea baltica (Pallas)	12.6	0.31	1.68	25.07	9.63
Decapoda					
Crangon crangon (Linne)	1.07	0.02	1.98	2.14	+
Mollusca					
Gasropoda veliger	1.51	5.75	2.14	11.9	4.57
Pisces					
Engraulis encrasicholus ponticus L.	12.27	1.85	1.81	44.9	17.25
Sprattus sprattus phalericus L.	6.56	0.79	5.46	41.00	15.75

%F = frequency of occurrence; %Cn = percentage of numerical composition;
%Cw = percentage of gravimetric composition: IRI = index of relative importance.

and prey species found in stomachs. According to the IRI, fish *Engraulis encrasicholus ponticus* (IRI=1388.58) and *Sprattus sprattus phalericus* L. (IRI=683.91) were the most frequently consumed prey items, followed of two Mysidacea: *Mesopopsis slabberi* (van Beneden) (IRI= 652.96) and *Paramysis lacustris* (Mart) (IRI= 198.92). Polychaeta *Terebellides stroemi* (Sars) (IRI=281.57) were the most important (IRI) followed by two Copepoda: *Pseudocalanus elongates* (Beock) (IRI=127.92) and *Acartia clausi* (Giesbracht) (IRI=63.66). Other taxa found in the stomach contents were of lesser importance in the diet.

Food in Relation to Fish Size

From investigated prey groups most important for the diet of horse mackerel are Mysidacea and Pisces (Figures 4 and 5), as Mysidacea reached 35% in the stomachs of the size group TL =11cm and Pisces (*Engraulis engrasicholus ponticus* L. and *Sprattus sprattus phalericus* L.) accounted 55.11% in 15 cm size class. The highest differences between the hinges were found in Pisces and Mysidacea, since the box plot (Figure 5) shows relative homogeneity as regards the medians and spreads of rest of the prey groups i.e. contribution of the other groups was comparatively low. The frequency of Mysidacea (χ^2 = 53.4, df =10, p = 0.899) decreased with increasing of fish linear sizes. The variation of the prey groups in different size classes was as follows: Pisces χ^2= 44.3, df = 7, P = 0.0001, Amphipoda: χ^2 = 15.6, df = 8, P = 0.05; Cladocera: χ^2 = 12, df = 13, P=0.527; Mollusca: χ^2 = 12, df = 9, P = 0.196; Decapoda: χ^2=5.85, df = 8, P = 0.664; Polychaeta: χ^2 = 4.18, df = 7, P = 0.759; Copepoda χ^2 = 1.68, df = 13, P = 0.999. Due to high p-values the null hypothesis could be rejected only for Amphipods and Pisces. The variation of these prey groups in different fish size classes is significantly related to the fish size.

Seasonal Variation in the Diet Composition

In this study, we establish a next variation in food habits of horse mackerel within the season. Copepods and Pisces were the dominant prey groups in all seasons. Polychaeta were also present in the diet, with a peak value recorded in spring-summer

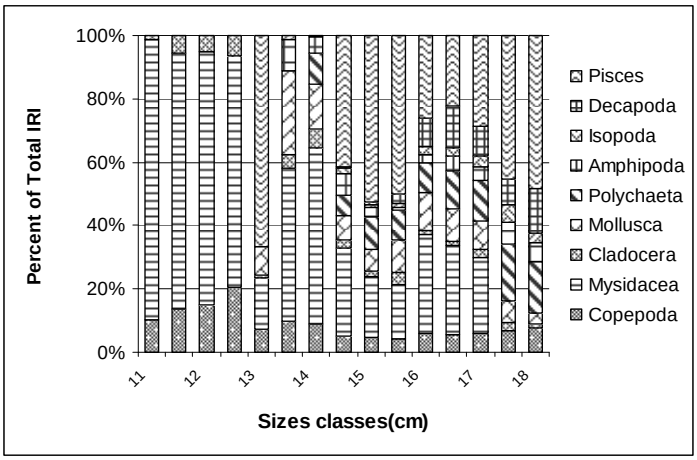

Figure 4. Composition of *Trachurus mediterraneus ponticus* diet as a function of size.

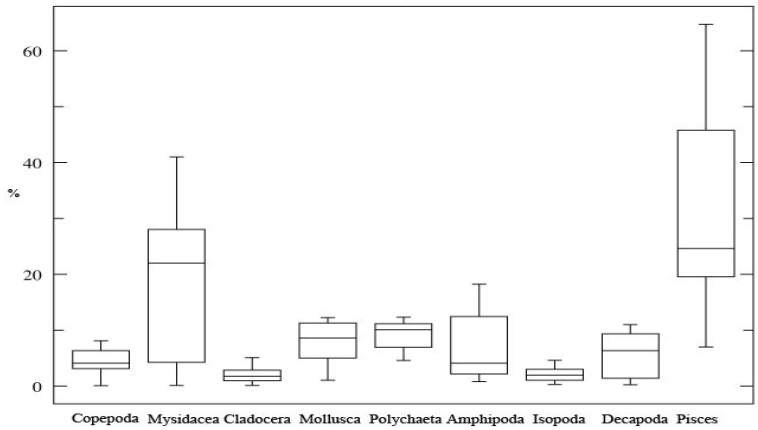

Figure 5. Boxplot (median value, 25-75% hinge, minimal and maximal observed percent participation) of the prey items from total investigated stomach samples.

period. Isopoda and Amphipoda were present in the contents during all seasons, but in smaller quantities (Figure 6), Cladocera (mainly *Podon polyphemoides*) were dominant prey group only in summer. Significant differences among seasons were found for Mysidacea (χ^2 =7.22, P<0.05), Cladocera (χ^2 =43.00, P<0.05), Polychaeta (χ^2 =12.9, P<0.05), Amphipoda (χ^2 = 4.50, P<0.05) while no significant seasonal differences were found for the other prey items, i.e. Copepoda (χ^2 = 0.54, P<0.05), Mollusca (χ^2 = 1.67, P<0.05), Isopoda (χ^2 = 0.50, P<0.05), Decapoda (χ^2 = 1.83, P<0.05), and Pisces (χ^2 = 3.58, P<0.05. Feeding activity increased upon spawning period (June and July) and was also higher during the summer. The lowest intensity of feeding was recorded in early spring during the lower sea temperature as well as at the time of intensive spawning.

Discussion

The data we obtained in this study show that the main prey of the Black Sea horse mackerel is fish and zooplankton. This group represents over 55% of the total IRI and was the main food for this species. In Albanian waters, *T. mediterraneus* prefers fish (particularly anchovies), amphipos, misids and decapods in the summer (Lipskaja, 1966). In the Aegean Sea, fish larvae and postlarvae (particularly of *Pagellus acarne*, *Diplodus vulgaris* and *Spicara maena*) constitute the dominant biomass in *T. mediterraneus* stomachs, followed by crustacean copepods and mysids (Kyrtatos, 1998). Descriptions of *Trachurus mediterraneus* diet in Izmir Bay state that the main food items are Mysidacea, *Brachyural* larvae and Copepoda (Sever and Bayhan, 1999). In the Portuguese coast, horse mackerel fed on fish; however, the main prey was crustaceans (Cabral and Murta, 2002). The data recorded in this work generally coincide with the above mentioned references, showing that zooplankton (especially at an early age) and fish dominate the diet of horse mackerel in Bulgarian Black Sea waters. Differences in food of horse mackerel diet between the different areas are mainly due to different distribution, abundance, density, availability and accessibility of prey (Šantič *et al*., 2004). Cladocera such as *Podon polyphemoides*, *Evadne nordmani*, *Evadne tergestina* and *Penlia avirostris* formed the food of individuals in summer season. Other preys, i.e. copepods, polychaetous worm, were of minor importance and thereby considered as occasional food. Pisces such as *Engraulis encrasicholus ponticus* L. *Sprattus sprattus phalericus* L. and decapods (e. g *Crangon crangon*) were the most important in the diet, especially in the largest size–groups (of over 15 cm TL). Data on the food of *Trachurus mediterraneus ponticus* in the Black Sea are very scarce. Stoykov (1978) mentioned that plankton crustaceous (during the spring season) and fish (during the autumn) represented in the stomach contents of horse mackerel as a food. The same author stated also that differences in the food items found in stomach are observed depending on time and place of catching. The changing feeding intensity of the examination period is most likely connected with different water temperature during the spring–summer. The highest values of stomach emptiness were recorded in April. The feeding intensity of Mediterranean horse mackerel changed during the year, probably related to spawning and water temperature (Šantič *et al*., 2004). Poorer feeding intensity in April is probably related to lower seawater temperature (in April 2007, sea surface temperature showed comparatively low values SST=8°C, as compared with the summer - SST=25.3°C). Feeding intensity increased in May-June (prior to spawning) and reached its lowest level during spawning (July–August). According the findings of to Sirotenko and Istomin (1978), feeding intensity for *Trachurus mediterraneus ponticus* from the Black Sea increased from 80 to 90% after spawning. The high seawater temperature in July–August accelerate metabolism, resulting in an

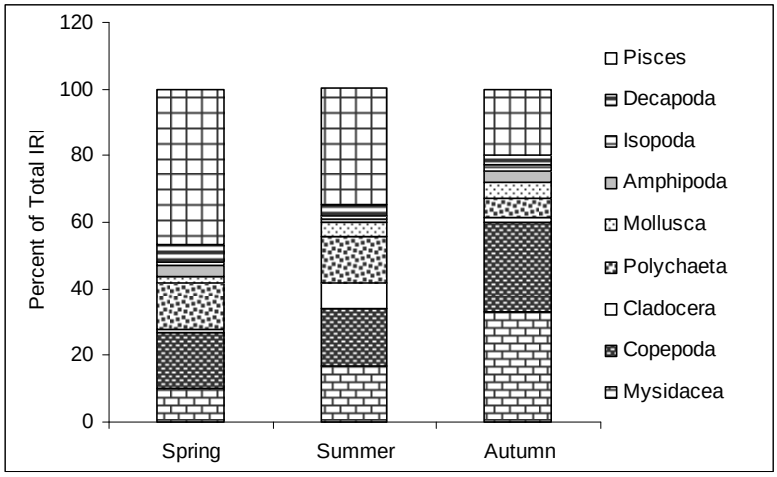

Figure 6. Diet composition of horse mackerel in the Bulgarian territorial waters during the seasons.

increased food demand (Šantič *et al*. 2004). Warren and Davis (1967) discussed the profound effect of temperature and seasonality on food consumption rates. In many fish, the feeding rate drops as the temperature drops (Tyler, 1971). Stoyanov *et al*. (1963) reported that reproductive activity of *Trachurus mediterraneus ponticus* started in May and lasted till August with peak in July. The last author concluded that spawning season of this species takes place during the warmer part of the year. Borges and Gordo (1991) reported that the percentage of empty stomachs in horse mackerel reached a peak in winter, which is the spawning season of this species on the Portuguese coast. Our study indicates that food habits considerably change as fish grows. Smaller specimens mainly feed on mysid crustaceans that are abundant and have small weights. As fish grow, the proportion of fish prey increases and that of crustaceans decreases. Data obtained in this study on the changes of food content are consistent with those of Stoyanov *et al*. (1963). Namely, Stoyanov *et al*. (1963) reported that *Trachurus mediterraneus ponticus* living in the Bulgarian territorial waters feed in summer with different development stages of small fish (anchovy, sprat) and crustaceans such as Mysidacea. The same authors revealed that zooplankton formed the food of young individuals. The crustaceans dominated in the diet of horse mackerel throughout the year. In 2007, larval stages of crustacea show significant increase in their density according Uzunova (pers. communication), which proves an improvement of feeding base of fish populations. The present analysis indicated that horse mackerel was the predator. Besides having the largest number of zooplankton, it had a high impact on populations of commercial fish such as sprat and anchovy.

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